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CURRENT SERIAL RECORD

Estimation and Maintenance of

SODIUM O-PHENYLPHENATE CONCENTRATION

in Sweetpotato Treating Solutions

AMS-521

UNITED STATES DEPARTMENT OF AGRICULTURE • Agricultural Marketing Service • Market Quality Research Division

WARNING

When sodium o-phenylphenate is used on sweetpotatoes, it should be used in such a way that the residue is not more than 15 parts per million of o-phenylphenol. This is the tolerance established by the Food and Drug Administration for residues in or on sweetpotatoes from postharvest application of this fungicide. Since this chemical may be harmful to man and animals, follow the directions and heed all precautions on container labels.

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Washington, D.C. December 1963

Summary

Several packinghouses are using solutions of sodium o-phenylphenate tetrahydrate (SOPP) to control decay of sweetpotatoes. After the sweetpotatoes have been washed, graded, and trimmed, they are immersed in, or sprayed with, the SOPP solution and then rinsed.

The roots carry some of the wash water into the solution and some of the solution away after the treatment. This addition of water and loss of solution dilutes the solution remaining in the tank.

The rate of dilution was studied in four packinghouses that immersed the sweetpotatoes in tanks containing the SOPP solution and in two that sprayed the solution onto the sweetpotatoes. Several methods were used to test samples of the treating solutions after known quantities of roots had been treated to determine the best way of testing the strength of the solution.

The dilution rate was faster when the solution was sprayed on than it was when the roots were dipped into the solution, because the roller conveyor that carried the sweetpotatoes through the spray carried water from the washer into the solution. The roller conveyor did not pass through the dip tank.

Tests to determine the strength of the solution with the 4-aminoantipyrine method were fairly satisfactory in the laboratory, but were unsatisfactory in the packinghouse. A test with the Folin-Ciocalteau reagent proved successful in five packinghouses.

The following recommendations are given for use of SOPP in treating sweetpotatoes:

Use a tank that will hold 50 gallons of solution for each foot of width of the grading equipment; that is, if the equipment is 4 feet wide, use a 200-gallon tank.

Use separate conveyors and drip pans for each section of equipment.

Do not use metals that an alkaline solution will corrode.

Check the concentration of the treating solution; keep the concentration between 0.8 and 1.0 percent for cured and 0.4 to 0.5 percent for noncured sweetpotatoes.

Estimation and Maintenance of Sodium O-Phenylphenate Concentration in Sweetpotato Treating Solutions

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Approval by the Food and Drug Administration of a residue tolerance of o-phenylphenol on sweetpotatoes[2] led to the commercial use of sodium o-phenylphenate in several packinghouses in North Carolina and Georgia during the 1961-62 season to prevent decay during marketing. A concentration range in the treating solutions of 0.8 to 1.0 percent for cured and 0.4 to 0.5 percent for noncured sweetpotatoes was recommended,[3] based on data obtained in earlier tests.[4] The percentages are based on the content of sodium o-phenylphenate tetrahydrate (SOPP) or Dowicide A.[5]

Commercially, washed, graded, and trimmed sweetpotatoes are immersed in, or sprayed with the SOPP treating solution, and then rinsed briefly before being packaged for shipment to market. After washing, the roots carry some water to the treating solution, and treated roots carry some treating solution away. This decreases the strength of the treating solution. In some installations conveyors also carry water from the washer to the treating solution and dilute it.

The rate of dilution was studied in four packinghouses using a dip-tank applicator and in two using a spray applicator. Methods of determining the strength of the commercial treating solutions were compared to select one suitable for general packinghouse use. Such a method must be simple, rapid, and reasonably quantitative.

Methods

Samples of treating solutions were removed from the treating tanks at intervals after known quantities of roots were treated. These samples were examined for concentration of SOPP.

Two methods (the Folin-Ciocalteau method and the 4-aminoantipyrine methods) recently developed for use with the same formulation used in these tests (Stop-Mold B) have been reported.[6] They were compared with a titrimetric method (bromine method) widely used for phenol determinations.[7] Adequate directions for the preparation of reagents and procedure may be found in the references cited.

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[1] The author is indebted to Dr. Ulo Kiigemagi, Department of Agricultural Chemistry, Oregon State College, Corvallis, Oreg., and Dr. Grant Smith, Agricultural Chemical Research, Dow Chemical Company, Midland, Mich., for pertinent information.

[2] Federal Register, p. 10454, Oct 25, 1960. (21 CFR 120. 129.)

[3] Covington, H. M. Treating Sweet Potatoes With SOPP. N.C. Agr. Expt. Sta. Hort. Inform. Leaf. 93. 1960.

[4] Kushman, L. J. Fungicidal Control of Decay in Porto Rico Sweetpotatoes During Marketing. A Progress Report. U. S. Dept. Agr., AMS-452, 18 pp. 1961.

[5] The use of brand names in this report does not constitute endorsement of the products named or imply discrimination against other products. Mention of these is primarily for information of others who may wish to use the methods described.

[6] (a) Kiigemagi, U., and Van Vleck, F., Jr. Field Estimation of Stop-Mold B Concentrations. Agr. and Food Chem. 10(5): 392-393. 1961. (b) Smith, G. N. A Field Test Kit for the Determination of O-Phenylphenol in Fruit Dipping Solutions. Down to Earth 18(2): 11-13. 1962.

[7] Scott, R. D. Application of a Bromine Method in Determination of Phenol and Cresols. Indus. and Engin. Chem., Analyt. Ed. 3: 67-70. 1931.

Standard solutions were made with both the raw chemical (SOPP) dissolved in water and the dilution of the formulated commercial stock solution based upon percentage composition by weight (34 percent anhydrous sodium o-phenylphenate) and specific gravity (1.124 at 70° F). Using the bromine method, these standards agreed very closely, and the stock solution developed from the formulated commercial stock solution was used as a standard for the comparison of methods and dilution rates.

For systems using dip tanks for application of the treatment solutions, conveyors 14 to 22 feet long carried the potatoes to the dip tank (50 to 220 gallons of solution), but the rollers themselves did not enter the dip tank (fig. 1). Thus, most of the free water remaining on the roots after washing drained from the roots before reaching the dip tank, and a minimum of water reached the treating solution.

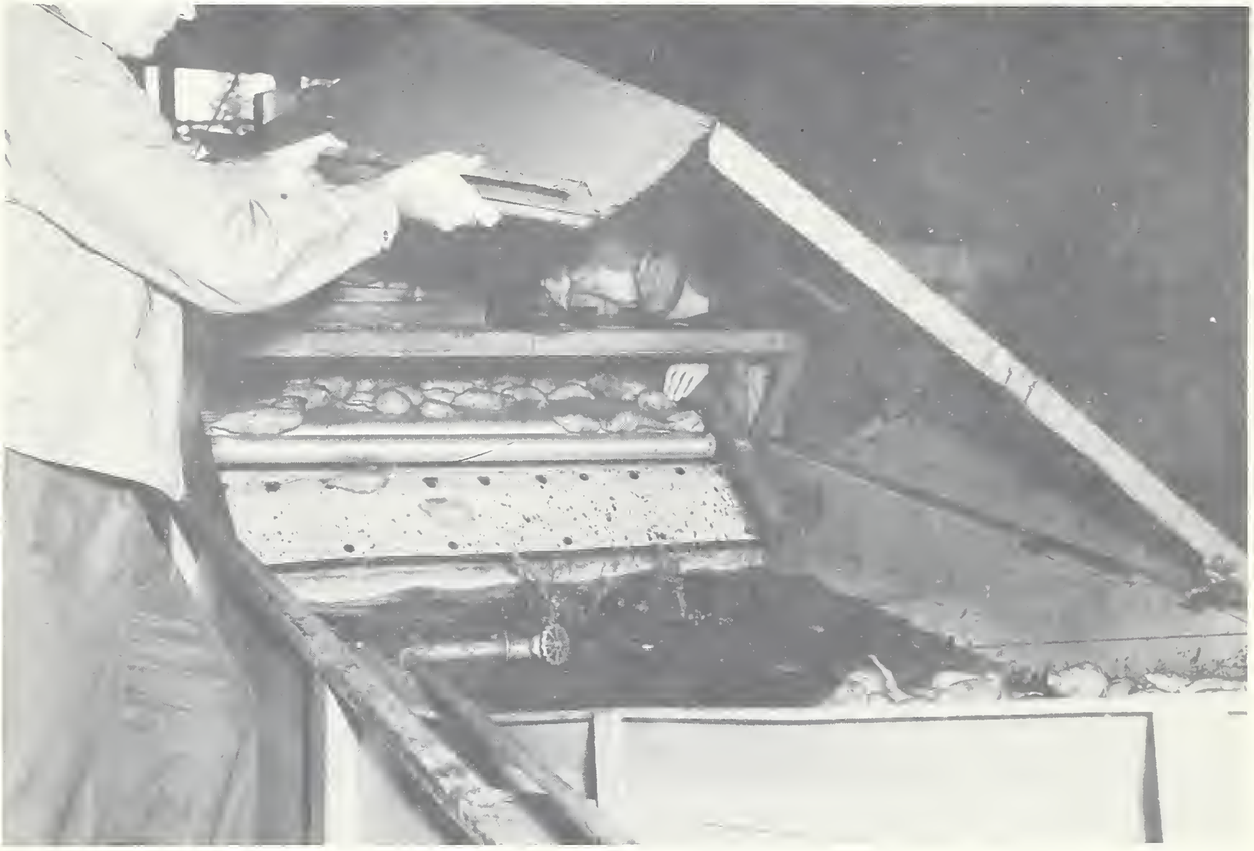

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Figure 1. --Sweetpotatoes going through a treating tank (left to right). The cover over the tank, here held up to disclose the treating solution, prevents loss of solution and splashing onto nearby workers. In this installation the roots are in the solution about 10 seconds, on the conveyor approximately 20 seconds where the excess solution drains off, and rinsed on another conveyor to the right, out of view in the picture.

In the spray applicator systems, the roller conveyor carrying the potatoes from the washer passed on through the spray applicator (fig. 2). A hood containing a double row of nozzles was mounted over the conveyor, and a reservoir beneath the conveyor collected the treating solution. Wash water was carried on the conveyor as well as on the roots into the reservoir. Thus, appreciable dilution of the treatment solution was possible. The treating solution drained back into the dip tanks or reservoir of the spray applicator over a distance of 6 to 10 feet of roller conveyor before the roots transferred to another roller conveyor on which the rinse was applied.

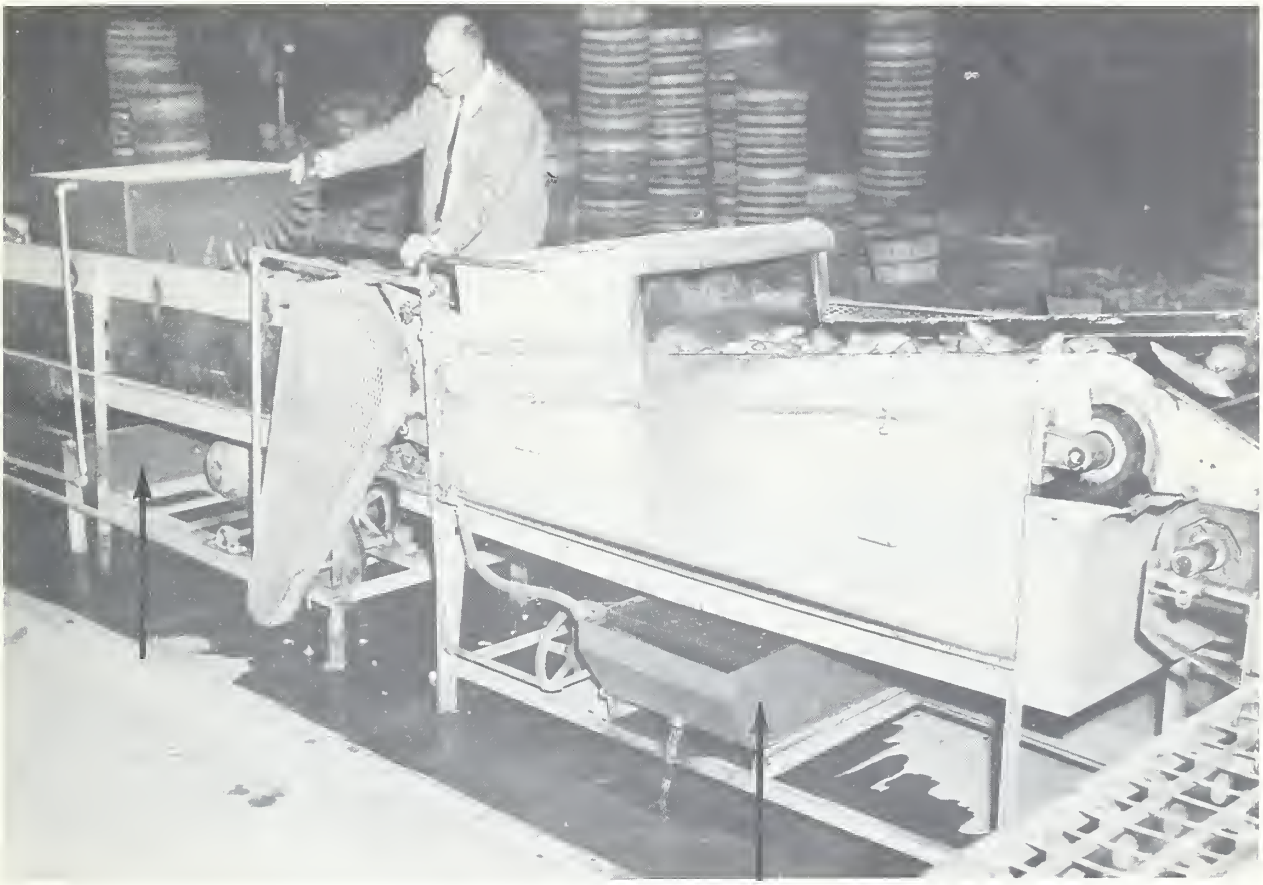

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Figure 2. --Sweetpotatoes going through a spray-type applicator (left to right). The worker is watching the spray application; the sweetpotatoes are rinsed with a similar spray at the right. The tanks below the conveyors contain the treating solution (left) and coloring and waxing solutions (right) which, when used, serve as a rinsing solution instead of water.

Results and Discussion

Dilution of treating solution. --Dilution of the treating solution depends upon the amount of water or treating solution carried on the roots to and from the solution tanks. Only an approximate measure of this was attempted because of the variation due to differences in size, shape, and surface characteristics of the roots as well as the thoroughness with which water was removed on the roller conveyors. Nevertheless, an estimate of 1 pound of water per 55-pound bushel of roots was made when washed samples were reweighed after overnight exposure in bushel baskets or when determinations were made on clean, dry roots immersed in water and placed on paper toweling for 15 seconds. If we assume that the same quantity of treating solution would be carried away from the treating equipment as the quantity of water carried in, about 5 to 6 gallons of each would be carried into or out of the tank for every 50 bushels of roots treated. One pint of stock solution containing 1/2 pound of SOPP would be required to produce a 1.00 percent solution with 6 gallons of water carried into the tank. This would replenish the treating solution to a theoretical concentration of 1.00 percent in a 100-gallon tank after 50 bushels of sweetpotatoes were treated.

This rate of dilution was tested with the first commercial treating tank. With the addition of 1 pint of stock solution, after successive lots of 50 bushels of roots were put through a treating tank, the concentration increased from 1.02 percent to 1.05, 1.08, and 1.10. Recalculation determined that the addition of 0.77 pint of stock solution per 100 bushels treated maintained the desired concentration (table 1).

Table 1.--Dilution of sodium o-phenylphenate tetrahydrate (SOPP) treating solution in a 100-gallon tank by immersion of cured sweetpotatoes during grading, packinghouse A

Bushels of sweetpotatoes treated	SOPP concentration	
	Before adding stock solution	After adding stock solution[1]
	Percent	Percent
0	1.06	---
137	.99	[2] 1.05
200	.94	[3] 1.05

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[1] 34 percent anhydrous sodium o-phenylphenate or 46 percent by weight as the tetrahydrate.

[2] 1 pint stock solution added.

[3] 1.6 pints stock solution added.

Similar records were obtained at three other packinghouses while treating 500 to 1,000 bushels of roots. These records showed that 0.72, 0.81, and 1.01 pints of stock solution were required per 100 bushels immersed in the tanks to maintain concentration. The rate of dilution was highest with a 50-gallon tank and a 6-foot conveyor. The short conveyor did not allow all of the excess solution to drain from the roots in time to be recovered before the roots moved on to the next piece of equipment. The loss of treating solution reduced the quantity left in the tank and required the addition of water and stock solution to maintain the 50-gallon level.

Spraying the solution on roots carried on a roller conveyor allowed rapid dilution and produced wide variations in solution concentration in a 10-gallon-capacity reservoir (table 2). In a packinghouse with a 60-gallon reservoir spraying unit, the dilution rate required 0.95 and 1.1 pints of stock solution per 100 bushels of roots treated to

Table 2.--Dilution of sodium o-phenylphenate tetrahydrate (SOPP) treating solution in a 10-gallon tank by spraying 400 bushels of cured sweetpotatoes during grading, packinghouse D

Bushels of sweetpotatoes treated	SOPP concentration	
	Before adding stock solution	After adding 1 pint of stock solution[1]
	Percent	Percent
0	1.06	---
50	.58	0.77
50	.38	.48
75	.26	.57
75	.25	.42
75	.38	.58

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[1] 34 percent anhydrous sodium o-phenylphenate or 46 percent by weight as tetrahydrate.

maintain the concentration on 2 different days. Additional records of dilution rate for this type of application are needed before an average rate for this method can be developed. The dilution rate is faster with the spray unit than with dip-tank application because wash water carried on the roller conveyor (as well as on the roots) goes into the reservoir. If the roots coming from the washer were transferred to another conveyor before treatment, the dilution rate should be similar to that obtained with the dip-tank type of application.

Determination of concentration.--Because of the many variables encountered in application, including design and construction of equipment, and size, shape, and surface characteristics of roots, a method for quantitative analysis of the treating solution was necessary. One hundred gallons of 1.0 percent strength treating solution contains 2 gallons of stock solution with a value of about $12 (based on 1963 prices). If too strong a solution is used, the sweetpotatoes may be injured. If the treating solution is too weak, decay control will be uncertain.

Tests with the 4-aminoantipyrine method proved fairly satisfactory in the laboratory. The differences in pink coloration of the standard solutions permitted a distinction of 0.2 percent SOPP as claimed. However, in the packinghouse two things made the method unsatisfactory: (a) Traces of the red dyes occasionally used to color the sweetpotatoes in the treating solutions led to false readings, and (b) the instability of some of the solutions used made the results erroneous at times.

The Folin-Ciocalteau reagent proved stable for one year if evaporation was prevented, and, with a little practice, fairly reliable readings were possible even with small amounts of red dye and dirt in the solution (table 3). Because of the amount of dirt in the treating solutions, the procedure of comparing the color developed with known standards[8] was abandoned. Instead, a crude titration was made by adding increments of

Table 3.--Concentration of sodium o-phenylphenate tetrahydrate in sweetpotato treating solutions as determined by two methods

Folin Ciocalteau method	Bromine method	Folin Ciocalteau method	Bromine method
Percent	Percent	Percent	Percent
1.0	[1] 1.02	1.0	1.10
.8	[1] .77	1.0	1.02
.6	[1] .51	.6	.77
.3	[1] .26	.6	.47
1.1	1.06	.5	.59
.7	.88	.5	.59
.6	.53	.5	.55
1.2	1.40	.5	.41
.6	.74	.4	.38
.9	.98	.3	.25
.9	.61	.3	.38
.7	.67	.3	.26

[1] Standard solutions; all others were obtained from commercial treating tanks.

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[8] See footnote 6(a).

a given treating solution to 5 milliliters of the Folin-Ciocalteau reagent in a 50-milliliter beaker until a noticeable change in color from yellow to blue or bluish gray was obtained. The concentration was estimated from the amount of treating solution required to produce this change. For comparison, about 7.5 milliliters of a 1.0 percent or 15 milliliters of an 0.5 percent solution produced the change. Some judgment is required to produce approximately the same degree of color change each time. Five packinghouse managers supplied with samples and instructions found the method practical and a valuable aid.

The Folin-Ciocalteau method has been tried with two other commercial formulations approved for use on sweetpotatoes (Stop-Mold A and Keep' em Fresh A) with results similar to those obtained with Stop-Mold B. One of the formulators is marketing the Folin-Ciocalteau reagent as an aid in maintaining concentration of treating solutions. Neither this method nor the bromine method gives satisfactory results if wax is present in the treating solution.

Commercially, the treating solutions are used to treat from 2,000 to more than 4,000 bushels before being discarded. In some packinghouses the solutions are made up Monday morning, used until Saturday, and then discarded. Samples taken after 2,000 to 3,000 bushels had gone through the treating tanks were quite dirty, but control of soft rot was still satisfactory, as judged by treated roots held a week or more at the packinghouse for observation.

A net loss of treating solution usually occurred because the roots carried a smaller volume of water into the tanks than the volume of treating solution which they carried away. The amount of this loss varied but was approximately 5 gallons per 500 bushels of roots treated. From time to time, water and stock solution must be added to compensate this loss.

Recommendations

The most appropriate size of dip tank or reservoir tank for treating sweetpotatoes with SOPP will depend upon several factors such as the capacity of the grading equipment, expected hours of operation per day or per week, and other details that involve equipment management. As a general guide it is recommended that tank capacities be in proportion to the width of the grading equipment used with the tank; that is, 50 gallons for each foot of width or 100-, 150-, and 200-gallon tanks in equipment 2, 3, or 4 feet wide, respectively. This is convenient since most grading equipment is scaled according to width, and this width usually reflects the capacity of the equipment to handle sweetpotatoes.

Separate conveyors and drip pans should be used for each section of equipment to minimize dilution or loss of treating solution. Since the treating solution is alkaline, metals such as aluminum or galvanized parts will be corroded by it and should be avoided.

Specific instructions concerning the dilution and use of the stock solutions are usually provided with the stock solution. These instructions are based, in part, on the data presented in this report and compensate for anticipated dilution of the treating solution with use. Some means of checking the concentration of the treating solution should be used, especially until experience with the equipment being used establishes a routine. The Folin-Ciocalteau reagent is recommended for this purpose. The procedure for using it, or any other that may be available, should be practiced with treating solutions of known strength made by carefully diluting small amounts of stock solution.